Parkways or Freeways: Safety Performance Linked to Corridor Landscape Types

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ABSTRACT

The design of a modern urban freeway is based on providing a high level of service and enhanced safety. It is generally assumed that modern freeway characteristics of paved shoulders, concrete median barriers and extended vegetation clear zones represent safety related design elements. On the other hand, parkways are characterized by grassed shoulders and medians with trees and other landscape elements within 30ft. of the edge of the driving lanes. Based on the assumed safety properties of the modern freeways and parkways, this research compared the safety performance of parallel sections of freeways and parkways in terms of fatal accident rate and an accident cost measure.

The results of this study showed that the parkway sections were significantly safer in terms of fatal accident rate per one hundred million vehicle miles traveled and significantly lower accident cost of fatal crashes per one million vehicle miles traveled than the compared freeway sections. Particularly, urban parkway sections were significantly safer in terms of fatal accident rate and lower accident cost than the other compared sections in this study. Also, urban parkway sections showed the lowest proportions of 'drowsy' and 'inattentive' driver factors in fatal crashes of the four types of study sites: rural parkway, rural freeway, urban parkway, and urban freeway sections.

OVERVIEW

There is a very limited body of research dealing with the impact of landscape character on driver safety. However, recent work by Kaplan, has suggested that there is a relationship between travelway landscape characteristics and driver visual preference (*1*). Parsons et al. conducted research that suggests a connection between travel-related stress and the visual character of the travelway corridor (*2*). Bahar and Naderi's work suggested that there was a correlation between urban landscape developments and safety (*3*). Because there appears to be a strong driver preference for the aesthetic character of parkway type highways compared to the typical freeways this foundation prompted a group of researchers at Texas A&M University and The Texas Transportation Institute to systematically examine the safety performance of parkways as compared to parallel sections of freeways, and to examine the safety impact of landscape improvements on a variety of urban highways. The objectives of the research were: 1) Compare the safety performance of parallel sections of parkway and freeway and 2) compare the safety performance of highway sections before and after landscape improvements. This paper focuses on the research results of comparison studies on the safety performance of parallel sections of parkway and freeway.

RESEARCH METHODOLOGY

To compare the safety performance of parkways compared to freeways, which are Interstate highways and U.S. highways, case studies for a number of candidate sites were reviewed. From the candidate sites, twelve paired sites were selected for comparisons. These 12 pairs represent 4 different states, and 5 of the pairs are in densely urbanized areas. Accident data at these 12 sites were collected from the Fatal Accident Reporting System (FARS) for seven years, from 1994 to 2000. In total, 168 study cases were examined to compare the safety performance of parkways and freeways. The experimental design using parallel highway sections is a quasi-experimental approach. This method was utilized because it was not possible to randomly assign segments for comparison (*4,5*).

To minimize the threats to reliability, the concept of multiple case studies was applied to the research. Using multiple locations and different times, separates the "uniqueness" of a particular location, and the likelihood of falling to "an unknown threat". Likewise, the increase in accident data obtained by using multiple locations, helps increase the statistical validity (*6*).

Control variables were developed by careful case selection, data filtering, and data analyses. These control variables help the internal validity of the study. The concept of multiple case studies and the control variables permits causal inferences between highway landscape and traffic safety. A description of the landscape differences between parkways and freeways, the variables for comparisons, and the control variables in this study follow.

Landscape Differences between Parkways and Freeways

Selected comparison sections of parkways and freeways differ in that parkways are generally assumed to have higher aesthetic landscape values. Parkways have well landscaped edges, grass shoulders, vegetated medians, and an appropriate landscape transition between travelways and surroundings, while freeways have paved shoulders, concrete median barriers, and limited landscape transitions (Figure 1). This landscape difference between parkways and freeways constitutes the independent variable in this study.

Variables for Comparisons

The Fatal Accident Rate (FAR) and the Accident Cost (AC) constitute the dependent variables for comparing the safety performance of parallel sections of selected parkways and freeways. The FAR is the number of fatal accidents per 100 million Vehicle Miles Traveled (VMT) and considered the most accurate means of measuring highway safety trends (*7*). The Fatal Accident Rates were used to compare populations being exposed to fatal accidents at those parallel sections of freeways and parkways in this study.

In addition, the costs per injury by a severity scale, which was suggested by the Federal Highway Administration (*8*), was applied to calculate the accident costs of fatal crashes per one million VMT. The accident costs were used to compare the social costs of fatal crashes at those parallel sections of freeways and parkways. The accident costs include all cost components, which are: property damage, lost earnings, lost household production, medical costs, emergency services, travel delay, vocational rehabilitation, workplace costs, administrative, legal, and pain and lost quality of life. The fatal accident rates and the accident costs at twelve parallel comparison sections over a seven-year period were calculated using data extracted from the FARS data sets. The calculation formula and concept of the FAR and the AC are described in the Data Analyses and Findings sections.

Control Variables

The following control variables constituted during case selection were:

- locality,
- regional landscape type,
- length of road section,
- number of travel lanes,
- speed limit,
- roadway function class, and
- climatic condition.

Variables controlled in the data filtering procedures and data analyses were:

- construction/maintenance zone relation,
- alcohol/drug involvement,
- traffic volume, and
- access control.

CASE SELECTION

At the stage of case selections, the parkways and the freeways were required to have the following characteristics in common.

- Freeway and parkway segments within the same locality had to have relatively the same origin and destination.
- Segments should be generally parallel through out the corridor.

The case selection criteria above controlled variables such as locality, regional landscape type, and climatic condition because parallel comparison sections of parkway and freeway in the pairs are located very closely within the same geographical area and same locality. Therefore, they may meet similar climatic changes and have similar regional landscape types. In addition, the comparison sections were required have similar lane length, the same interval in number of travel lanes and the same class of roadway function, as well as the same interval of speed limit. Particularly, posted speeds for each road in the pairs of parkway and freeway sections had to be similar. The classified number of travel lanes, roadway function class, and speed limit were:

- Comparison sections had similar lane length.
- Travel lanes in one direction: <2, 2-4, 4-6, and >6 lanes.
- Roadway function classes: Interstate/Expressway and Non-Interstate.
- Speed limits: ≤55 mph and >55 mph.

In addition, the researchers tried to obtain pairs that were used as commuting highways in order to control driver experience. Under the criteria mentioned above, twelve parallel comparison sections were selected from a number of candidate sites (Table 1).

DATA COLLECTION & FILTERING

Accident data was extracted for study sections from the FARS data for seven years (1994-2000). The reason for using only the FARS data was that this was the only available data set that was sufficiently consistent to allow comparison across state lines. Data on non-fatal or property damage accidents was not sufficiently consistent to be used for purposes of comparison. Although the use of the FARS data limited the research somewhat because it does not represent all types of crashes, the data can give a good perspective to overview the safety performance according to corridor landscape types. The accident data from the FARS were extracted based on four data categories as follows:

- Crash factors: date (mm/dd/yy), day of week, crash time, atmospheric condition, construction/ maintenance zone relation, city, county, light condition, manner of collision, crash related factors, milepoint, number of fatalities in crash, number of travel lanes, relation to roadway, relation to junction, roadway surface condition, speed limit, traffic-way identifier, traffic-way flow, and traffic control.
- Vehicle factors: number of vehicles in crash, travel speed, and types of vehicle.
- Person factors: this category provides data on the kinds of people involved in and killed in motor vehicle fatalities. This includes drivers, occupants, bicyclists, passengers and pedestrians, among others. For example, this includes data such as occupant age, injury severity, police-reported alcohol involvement, police-reported other drug involvement, and sex etc.
- Driver factors: driver age, sex, and driver related factors (drowsy, fatigue, inattention, operation error, excessive speed, failure to obey traffic regulations, pedestrian and motorcyclist crashes, relation to live animal in road, and relation to headlight glare etc.).

The roadway inventory data were obtained from each state Department of Transportation and city transportation department. This roadway inventory data was used to confirm whether paired sections of selected parkways and freeways were soundly comparable in terms of roadway and traffic operation factors. The roadway inventory data were collected based on two data categories:

- Roadway factors: number of travel lanes, length of road sections, median type/width, shoulder type/width, number of intersection (and interchange), and milepoint.
- Traffic operation factors: speed limit, traffic volume, function class, and access control.

The milepoint data made it is possible to refer the crash locations on the study sections because the FARS data is coded in milepoint. In addition, lengths of road section and traffic volume data were also used in the calculation of the FAR in order to bring the selected sections of parkways and freeways to the standardized comparison.

Data filtering controlled variables such as construction/maintenance zone relation in crash factors, alcohol/drug involvement in person factors, and access control in traffic operation factors. Construction/maintenance zone related and alcohol/drug involved fatal crashes were ruled out in the calculation of the FAR and the AC because it can be generally assumed that they are not related with the highway landscape characteristics. To control the accessibility between two comparison highway sections when the access control of two roads is different, intersection/entrance/exit ramp related fatal crashes were also ruled out from the fatal accident data extracted from the comparison highway sections (Table 2 and 3).

DATA ANALYSES & FINDINGS

The data analyses address four major research issues: 1) comparisons of safety performance of parkways and freeways for 12 parallel sections in terms of the FAR and the AC, 2) the analyses of the FAR and the AC in terms of localities, 3) the analyses of the fatal crashes in terms of driver related factors, and 4) the analyses of the fatal crashes in terms of relation to roadway.

The Fatal Accident Rates and The Accident Costs

The fatal accident rates at study sections were calculated in this data analysis. The number of fatal accidents at study sections was converted into the fatal accident rate based on standardized comparable criteria in order to bring selected sections of parkways and freeways to parallel comparisons. Through the calculations of fatal accident rates, the variables, traffic volume and the length of road sections of the selected parkways and freeways were controlled. The calculation formula for the FAR is described below:

$$\text{Fatal Accident Rate (FAR)} = \frac{\text{Number of Fatal Accidents} \times 100 \text{ million}}{\text{VOL} \times \text{The Length of Section} \times 365}$$

Where:

- Fatal Accident Rate = Number of fatal accidents per 100 million Vehicle Miles Traveled (VMT) at a study road section in a year
- Number of Fatal Accidents = Number of fatal accidents at a study road section in a year
- VOL = Average of Average Annual Daily Traffic (AADT) volume at a study road section
- The length of section = The length of a study road section

The Federal Highway Administration (FHWA) suggested the accident costs per injury by K-A-B-C scale severity (*8*). The costs were originally recommended as the values to use in benefit-cost analyses as the willingness-to-pay to avert a fatality.

Severity	Cost per injury (1994 Dollars)
K (fatal)	$ 2,600,000
A (incapacitating injury)	$ 180,000
B (non incapacitating or evident injury)	$ 36,000
C (possible injury)	$ 19,000
PDO (property damage only)	$ 2,000

The accident cost of fatal crashes per one million VMT was used in order to compare social costs of the fatal accidents of parallel sections of parkways and freeways in this study. The calculation formula for the AC is described below:

$$\text{Accident Cost (AC)} = \frac{(2{,}600{,}000K + 180{,}000A + 36{,}000B + 19{,}000C + 2{,}000PDO)\times 1{,}000{,}000}{VOL \times \text{The Length of Section} \times 365}$$

Where:

- Accident Cost = Accident cost of fatal crashes per one million VMT at a study road section in a year
- K = Number of 'fatalities' at a study road section in a year
- A = Number of 'incapacitating injuries' at a study road section in a year
- B = Number of 'non incapacitating or evident injuries' at a study road section in a year
- C = Number of 'possible injuries' at a study road section in a year
- PDO = Number of 'property damage only' at a study road section in a year

The average of fatal accident rates and accident costs over 7 years at each study comparison location was calculated using the formula of the FAR and the AC. Then the average scores at 12 comparison locations were listed to compare the safety performance of parallel sections of parkways and freeways (Table 4). The analyses suggested that the nine parkway sections were safer than the compared freeway sections in terms of the FAR. The parkway sections were significantly safer in terms of the FAR than the compared freeway sections at 95% confidence level according to one-sided paired t-test (p-value is 0.0302). This statistical test indicates the probability of exposure to fatal accidents per 100 million VMT at parkway sections was significantly lower at 95% confidence level than the probability at compared freeway sections.

For accident costs, ten parkway sections showed lower accident cost than the compared freeway sections. The parkway sections were also significantly lower accident cost than the compared freeway sections at 95% confidence level according to one-sided paired t-test (p-value is 0.0245). This means the social cost to avert fatal accidents per one million VMT at parkway sections is significantly lower at 95% confidence level than the cost at compared freeway sections.

Analyses of the FAR and the AC by Locality

To study the safety performance of parallel sections of parkways and freeways by the locality, the comparison of parkway and freeway sections by locality were done based on the FAR the AC.

The difference in the average of the FAR and the AC between urban freeway and parkway sections is much larger than the difference between rural freeway and parkway sections (Table 5). In particular, the results showed a difference almost twofold between urban freeway and parkway sections in terms of the FAR and the AC (Table 5). On the other hand, rural cases showed a smaller difference between freeway and parkway sections, which indicates that the urban parkway sections are much safer in terms of the FAR and the AC than the compared urban freeway sections in this study. Therefore, the corridor landscape type in urban settings appears to be a more meaningful variable than it is in rural settings.

Analyses of the Fatal Crashes in terms of Driver Related Factors

In this study, the 92 driver factors recorded in the FARS data set related to fatal crashes were reclassified into 11 major factors mostly found in the fatal crash data of this study. The major driver factors were:

- Alcohol and drug,
- Drowsy: sleepy, asleep, and fatigued,
- Inattentive,
- Running off road or failure to keep in proper lane,
- Driving too fast for conditions or in excess of posted maximum,
- Failure to obey traffic rules: failure to yield right-of-way, traffic sign, and safety zone traffic laws, etc.,
- Driver error: improper erratic lane changing,
- Operation error: erratic operation and operation inexperience,
- Weather or wet surface conditions,
- Other: debris in road, live animal in road, tree/billboard/other structure collisions, pedestrian or motorcyclist involvements, stopping in road, leaving vehicle in road, parked vehicle, driving on wrong side of road, unfamiliar with roadway, reflected glare/bright sunlight/headlights related, ill, blackout, other obstruction, and hit-and-run, etc., and
- Unknown and none.

In many accidents, several driver factors are often simultaneously related to a fatal crash. In those cases, each driver factor was cited in the fatal crash. Sometimes, this results in an exaggerated weighting of driver factors.

The proportion of a driver factor means the proportion of each factor from all driver factors involved in fatal crashes (Table 6). The driver factors were analyzed based on 284 fatal crashes on freeway sections and 172 fatal crash data on parkway sections.

The analysis shows that 'alcohol and drug', 'running off road', and 'driving too fast' were most prevalent on parkway sections, and are relatively higher than the proportions on freeway sections. On freeways, the proportion of 'failure to obey traffic rules' and 'other' driver factors are relatively higher than for parkway sections (Table 6).

The 'drowsy' and 'inattentive' driver factors in fatal crashes were analyzed in terms of locality. The overall proportion of 'drowsy' and 'inattentive' factors in fatal crashes on parkways was a little higher than for freeways. However, on urban parkways the 'drowsy' and 'inattentive' factors are much lower than the proportions at urban freeway sections. In rural parkway sections, the proportions of 'drowsy' and 'inattentive' factors are significantly higher than at rural freeway sections (Table 7).

The proportion of 'drowsy' and 'inattentive' factors at four types of study sections was also analyzed. The proportions of 'drowsy' and 'inattentive' factors were as follows: rural parkways (34.15%), rural freeways (14.60%), urban parkways (11.11%), and urban freeways (19.49%). The data shows 'drowsy' and 'inattentive' factors to be lowest of all others in urban parkway sections (Figure 3).

The driver factors in the 'other' category were also counted. The results indicate that the 'reflected glare, bright sunlight, and headlights' factors were reported in four fatal crashes of the total 284 fatal crash data at urban and rural freeways. On the other hand, there were no fatal crashes related to the headlight or sunlight glare at parkways.

On freeways, there were two fatal crashes related to the 'live animal in road' factor, one related to a 'motorcyclist', and one related to a 'pedestrian'. There were no 'tree collisions' of the 284 fatal crashes studied. On the parkways, there was just one fatal crash related to the 'live animal in road' factor. There was no reported fatal crash related to 'motorcyclist', 'pedestrian', and 'tree collisions' of the 172 parkway accidents in the data set.

Analyses of the Fatal Crashes in terms of Relation to Roadway

The relation to roadway of the fatal crashes in this study was classified based on the roadway classifications of the FARS data set. The classified relation to roadway was as follows: on roadway, shoulder, intersection/entrance/exit ramp, median, roadside, running off road and outside of right-of-way, gore, construction and maintenance zone, and unknown and none.

The analysis showed that the proportions of the 'roadside' and 'running off road and outside of right-of-way' crashes on parkways are relatively higher than the proportions at freeways. On the other hand, the proportions of 'on road', 'shoulder', and 'intersection/entrance/exit ramp' in fatal crashes on parkways are relatively lower than the proportions at freeways (Table 8).

CONCLUSIONS & FURTHER RESEARCH NEEDS

The parkway sections in this study were significantly safer in terms of fatal accident rate (FAR) and lower accident cost (AC) per one million VMT than the compared parallel freeway sections. These results show a positive correlation between the safety performance of parkway type corridors compared to freeways. What was even more striking was that urban parkways showed significantly better safety performance when compared to parallel freeway sections. The factors contributing to accidents were also interesting to note. On the parkways the highest percent of accidents were related to alcohol and drugs, speeding and running off the road. On freeways, more accidents were related to violation of traffic rules, driver factors, roadway, shoulder, ramp and interchange incidents. Taken together it appears that accidents on freeways tend to happen on the road and shoulder rather than on the right-of-way. This may be attributed to the wider use of guardrail and median barriers on freeways. Since parkway accidents were more frequent on the right-of-way, one would have expected more tree collisions. However, the opposite was true. For the sections studied, there was no car/tree collisions resulting in fatalities

This current study does not allow conclusions about any specific landscape elements or settings that may be contributing to the decrease in collisions and accidents. However, the consistent reduction in the number and cost of collisions across several states, types of climate, and landscape type strongly support the need for further detailed investigation of this phenomenon.

In order to identify specific landscape and environmental correlates that contribute to improved safety performance, site investigations and more detailed analysis of accidents in relation to the corridor landscape are needed. A wider range of transportation facility types, climate types, and landscape types also need to be studied in more detail. This type of detailed analysis was beyond the scope of this study, which had to rely on existing data sets.

In the final analysis it may well be that the public's demand for more aesthetic roadways and more context sensitive transportation design is also paying an unrecognized safety dividend particularly in our urban centers.

REFERENCES

1. Kaplan, R. Preference and Everyday Nature: Method and Application. In *Perspectives on Environment and Behavior: Theory, Research, and Applications*, ed. Stokols, D., Plenum, New York. 1977.
2. Parsons R., L. Tassinary, R. Ulrich, M. Hebl, and M. Alexander. The View from The Road: Implication for Stress Recovery and Immunization. *Journal of Environmental Psychology*. 18, 1998, pp. 113-140.
3. Bahar, G., J. Naderi. An Integrated Approach to Environmental Impact Mitigation and Safety Management-Case Studies in The Municipality of Metropolitan Toronto. In *Session: Roads/Transportation and The Environment, XIIIth World Meeting of the International Road Federation Toronto*, Ontario, Canada. 1997.
4. Cook, T., D. Campbell. *Quasi-Experimentation-Design & Analysis Issues for Field Settings*. Rand McNally College Publishing, Chicago. IL. 1979.
5. Council, F., D. Reinfurt, B. Campbell, F. Roediger, C. Carroll, A. Dutt, and J. Dunham. *Accident Research Manual*. Highway Safety Research Center, University of North Carolina, Chapel Hill, Jan. 1980.
6. Griffin, L. *Three Procedures for Evaluating Highway Safety Improvement Programs*. TARE Technical Report No. 51. Texas Transportation Institute, Texas A&M University, College Station, TX. 1982.
7. Accident Reconstruction Network under the Courtesy of National Motorist Association. Making Sense of Highway Safety Data. http://www.accidentreconstruction.com/news/info3.asp. Accessed Sep. 29, 2001.
8. Motor Vehicle Accident Costs. In *Technical Advisory T7570.2*. FHWA, U.S. Department of Transportation, Oct. 31, 1994.
9. Council, F., J. Stewart. Severity Indexes for Roadside Objects. In *Transportation Research Record 1528*, TRB, National Research Council, Washington, D.C., 1996, pp. 87-96.
10. Stewart, J. Applications of Classification and Regression Tree Methods in Roadway Safety Studies. In *Transportation Research Record 1542*, TRB, National Research Council, Washington, D.C., 1996, pp. 1-5.

LIST OF TABLES

LIST OF FIGURES

TABLE 1 Parallel Comparison Locations and Sections

Study **L**ocations	**F**reeways vs. **P**arkways	**C**ities or **S**tate	**S**ections
No. 1	IH-495 vs. Grand Central Pkwy	City of New York	IH 678 - Nassau Co. line
No. 2	IH-678 vs. Cross Island Pkwy	City of New York	IH-678: JFK Airport - Whitestone Bridge, CI Pkwy: St. Hwy 27 - Whitestone Bridge
No. 3	IH-495 vs. Northern St. Pkwy	New York	St. Hwy 106 - St. Hwy 231
No. 4	US-27 vs. Southern St. Pkwy	New York	St. Hwy 110 - St. Hwy 111
No. 5	IH-95 vs. Hutchinson River Pkwy	New York	Westchester Co. line - IH 287
No. 6	US-9 vs. Taconic St. Pkwy	New York	US-9: IH 84 - St. Hwy 308, Taconic St. Pkwy: IH 84 - St. Hwy 199
No. 7	IH-95 vs. Baltimore Washington Pkwy	Maryland	IH 495 - Baltimore City line
No. 8	US-9 vs. Garden St. Pkwy	New Jersey	St. Hwy 47 - Atlantic Co. line
No. 9	US-9 vs. Garden St. Pkwy	New Jersey	Burlington Co. Line - Co. Rt. 618
No. 10	IH-95 vs. Merritt Pkwy	Connecticut	IH-95: US 1 - US 1, Merritt Pkwy: St. Hwy 124 - St. Hwy 58
No. 11	IH-95 vs. Merritt Pkwy	Connecticut	IH-95: US 1 - St. Hwy 110, Merritt Pkwy: St. Hwy 58 - St. Hwy 110
No. 12	IH-91 vs. Wilbur Cross Pkwy	Connecticut	IH-91: IH 95 - St. Hwy 22, WC Pkwy: St. Hwy 69 - St. Hwy 22

TABLE 2 Summary of Variables

Variables			Descriptions
Control Variables	Roadway factors	Locality	Parallel comparison sections of freeways and parkways should be selected within the same locality.
		Regional landscape type	The types of regional landscape were controlled because the comparison sections were selected within the same geographical area.
		Length of road section	First, similar lengths of comparison sections were selected (Figure 2). Second, the lengths of road sections were also standardized when the FAR was calculated based on the number of fatal accidents per 100 million VMT.
		Number of travel lanes[1]	Parallel comparison sections of freeways and parkways have the same interval in number of travel lanes. The intervals are as follows: <2, 2-4, 4-6, and >6 lanes (in one direction).
	Traffic operation factors	Speed limit[2]	Parallel comparison sections of freeways and parkways have the same interval of speed limit. The intervals are as follows: ≤55 mph and >55 mph.
		Traffic volume	The traffic volume was controlled when the FAR was calculated based on the number of fatal accidents per 100 million VMT.
		Highway function class[3]	Parallel comparison sections of freeways and parkways have the same class of roadway function. The roadway function classes are as follows: Interstate/Expressway and Non-Interstate.
		Access control	Parallel comparison sections of freeways and parkways have the same access control. If comparison sections have different access control, intersection/entrance/exit ramp related to fatal crashes were ruled out to control accessibility (Table 3).
	Driver factors	Alcohol and drug involvement	To control the fatal crashes related to alcohol and drug related driving, police reported alcohol and drug involvement fatal crash data were ruled out.
	Crash factors	Construction and maintenance zone relations	To control the fatal crashes related to construction and maintenance zone, the construction and maintenance zone related fatal crash data were ruled out.
		Micro-climatic condition	Parallel comparison sections of freeways and parkways were located in the same geographical area and just a few miles far away from each other. Generally, it was assumed that the micro-climatic condition was controlled (Figure 2).
Independent Variables	Landscape difference between parkways and freeways		Parkways are generally assumed to be higher landscape values that indicate well-landscaped edges, grass shoulders, vegetated medians, and an appropriate landscape transition between travelways and surroundings while freeways generally do not.
Dependent Variables	Fatal accident rate		The number of fatal accidents on a per 100 million vehicle miles traveled (VMT).
	Accident cost[4]		Accident cost of fatal crashes per one million VMT.

1. Number of travel lanes is considered as an interval variable in many traffic safety researches. In cases of Council et al. (*9*) and Stewart's research (*10*) related to injury severity, the number of travel lanes was classified into two categories: two lanes and multilane.
2. Council et al. (*9*) and Stewart's (*10*) classification criteria for speed limit are applied to this research: ≤55 mph and >55 mph.
3. Stewart's (*10*) classification criteria for highway function class are applied to this research: Interstate/Expressway and Non-Interstate.
4. The costs per injury by a severity scale, which was suggested by the Federal Highway Administration, were applied to calculate the accident costs of fatal crashes per one million VMT.

TABLE 3 Summary of Parallel Comparison Sections of Parkways and Freeways

State	NEW YORK											
County	Queens Co.				Nassau & Suffolk Co.		Suffolk Co.		Westchester Co.		Dutchess Co.	
Roadway Identifier	IH-495	Grand Central Pkwy	IH-678	Cross Island Pkwy	IH-495	Northern St. Pkwy	US-27	Southern St. Pkwy	IH-95	Hutchinson River Pkwy	US-9	Taconic St. Pkwy
Length of road section	7.38 mile	7.42 mile	12.45 mile	11.89 mile	11.11 mile	12.03 mile	11.99 mile	12.62 mile	10.88 mile	11.43 mile	29.4 mile	30.32 mile
Function class	Urban Interstate	Urban Expressway	Urban Interstate	Urban Expressway	Urban Interstate	Urban Expressway	Urban Expressway	Urban Expressway	Urban Interstate	Urban Expressway	Rural Ma/ Mi Hwy	Rural Prin. Hwy
Access control	Free Limited	Free Limited	Free Limited	Free Limited	Free Limited	Free Limited	Free Limited	Free Limited	Toll Limited[1]	Free Limited[1]	Free Limited	Free Limited
Number of travel lanes[2]	3	3	2 - 4	2 - 4	3 - 4	3 - 4	3	3	3	3	2 - 3	2 - 4
Speed limit	50	50	50 - 55	50	55	55	40 - 55	55	55	50 - 55	40 - 55	55
Median type[3]	Divided, RCB	Divided, G/GPG/RCB	Divided, P / RCB	Divided, RCB / RCPB	Divided, P / RCB	Divided, G / GL	Divided P / RCB	Divided, G/GL/GPG	Divided, P / RCB	Divided, GL/GPG/RCB	Divided/None, P	Divided, G / GL
Median width	6 ft - 12ft	6 ft - 12 ft	6 ft - 12ft	6 ft - 12ft	6 ft - 12ft	12 ft - Varied	4 - 10 ft	12 ft - Varied	6 ft - 12ft	6 ft - Varied	0 - 6 ft	Varied
Shoulder width	0 - 10 ft	None[4]	0 - 10 ft	None[4]	0 - 10 ft	None[4]	N/a	None[4]	0 - 10 ft	None[4]	N/a	N/a
Traffic Vol.[5] (AADT)	158,924 ('97) 143,658 ('00)	131,146 ('97) 144,974 ('00)	127,148 ('97) 128,967 ('99)	122,318 ('97) 120,914 ('99)	142,226 ('94) 157,413 ('00)	74,070 ('98) 77,968 ('00)	63,692 ('97) 70,698 ('00)	111,717 ('97) 116,028 ('00)	89,815 ('97) 102,561 ('00)	85,061 ('97) 85,950 ('00)	31,333 ('95) 33,395 ('00)	12,757 ('95) 16,640 ('00)
Fatal crashes[6] ('94-'00)	8 (Except '94/'97)	5 (Except '94/'97)	29	7	26	14	33	14	11[1]	5[1]	20	12
FAR[7] ('94-'00)	0.3856	0.2679	0.7459	0.1849	0.6098	0.6040	1.6100	0.3825	0.4007	0.1996	0.8350	1.1580
AC[8] ('94-'00)	$ 11,642	$ 10,044	$ 21,178	$ 5,279	$ 18,286	$ 21,740	$ 51,828	$ 10,857	$ 12,924	$ 6,314	$ 25,410	$ 32,170

1. Intersection/entrance/exit ramp related fatal crashes in both comparison sections were ruled out to control accessibility.
2. Indicates the number of travel lanes in one direction.
3. Grass(G), Grass and Landscaped (GL), Guardrail and Planted Grass (GPG), Pavement without Barrier (P), Raised Concrete Barrier (RCB), and Raised Concrete Planted Barrier (RCPB).
4. Parkway sections in New York State have grass clearance or shoulder (about 0 ~ 10 ft) instead of asphalt pave shoulder in freeway sections.
5. Traffic volume indicates the volume in both directions. The AADT (or ADT) in this table indicates the average of the AADT (or ADT) at several points within a section at a specific year.
6. Construction and maintenance zone related and police reported alcohol and drug involvement fatal crashes in both comparison sections were ruled out to control alcohol and drug driving and work zone related fatalities.
7. The FAR means the number of fatal crashes per 100 million VMT. Above each FAR indicates the average of seven fatal accident rates (1994-2000) at each study section.
8. The AC means the accident cost of fatal crashes per one million VMT at each study section. Above each AC indicates the average dollars of seven ACs (1994-2000) at each study section ('94 dollars).

※ N/a indicates not available data.

TABLE 3 (Continued)

State	Maryland		New Jersey				Connecticut					
County	Anne Arundel, Baltimore, Howard, & Prince Georges		Cape May Co.		Burlington & Ocean Co.		Fairfield Co.				New Haven Co.	
Roadway Identifier	IH-95 vs. B-W Pkwy		US-9 vs. Garden State Pkwy		US-9 vs. Garden State Pkwy		IH-95 vs. Merritt Pkwy		IH-95 vs. Merritt Pkwy		IH-91 vs. Wilbur-Cross Pkwy	
Length of road section	23.2 mile	22.89 mile	23.98 mile	23.81 mile	30.8 mile	29.11 mile	12.53 mile	12.82 mile	7.28 mile	9.69 mile	7.56 mile	6.72 mile
Function class	Urban Interstate	Urban Expressway	Rural Minor Hwy	Rural Prin. Hwy	Rural Minor Hwy	Rural Prin. Hwy	Rural Interstate	Rural Expressway	Urban Interstate	Urban Expressway	Urban Interstate	Urban Expressway
Access control	Free Limited	Free Limited	Free Limited[1]	Toll Limited[1]	Free Limited[1]	Toll Limited[1]	Free Limited	Free Limited	Free Limited	Free Limited	Free Limited	Free Limited
Number of travel lanes[2]	2 - 4 (mostly 3~4)	2 - 4 (mostly 2-3)	2	2 - 3	2 - 4 (mostly 2)	2 - 3	3	2	3 - 4	2 - 4	3 - 4	2
Speed limit	55 - 65	55 - 65	35 - 50	35 - 55	35 - 50 [9]	35 - 65 [9]	55	45 - 55	45 - 55	45 - 55	50 - 55	55
Median type[3]	Divided, G/GL/RCB	Divided, G / GL	None or Curbed	None/Divided, G/GL/GPG	None/Divided Curbed, P	Divided, G / GL	Divided, RCB	Divided, GL / GPG	Divided, RCB	Divided, GL / GPG	Divided, G/GR/RCB	Divided, G/GL/GPG
Median width	Varied	Varied	0 - 3 ft	0 - Varied	0 - 9 ft	Varied	9 ft - Varied	Varied	9 ft - Varied	Varied	9 ft - Varied	Varied
Shoulder width	N/a	N/a	6 - 12 ft	10 - 12 ft	10 ft	10 ft	4 ft - Varied	None	4 ft - Varied	None	4 ft - Varied	None
Traffic Vol.[5] (AADT)	164,954 ('99)	71,796 ('99)	10,565 ('96)	21,650 ('95) 25,198 ('99)	15,490 ('95) 15,725 ('98)	46,300 ('95)	130,456 ('00) (ADT)	56,468 ('00) (ADT)	127,705 ('00) (ADT)	64,174 ('00) (ADT)	112,839 ('00) (ADT)	50,194 ('00) (ADT)
Fatal crashes[6] ('94-'00)	33	11	4 [1]	2 [1]	20 [1,9]	45 [1,9]	12	6	10	7	13	3
FAR[7] ('94-'00)	0.3375	0.2620	0.6333	0.1461	1.5561	1.2487	0.2873	0.3244	0.4210	0.4406	0.5965	0.3481
AC[8] ('94-'00)	$ 11,269	$ 7,108	$ 21,142	$ 4,262	$ 48,843	$ 40,610	$ 11,368	$ 8,531	$ 16,972	$ 15,092	$ 15,732	$ 9,259

9. Excessive speed driving related fatal crashes in both comparison sections are ruled out to control 'speed limit' at parallel comparison sections of the US 9 and the Garden State parkway.
※ N/a indicates not available data.

TABLE 4 The Fatal Accident Rates and The Accident Costs[1]

a) Fatal accident rates

Locations	Freeways	Parkways	Differences[2]
1	0.3856	0.2679	+0.1177
2	0.7459	0.1849	+0.5610
3	0.6098	0.6040	+0.0058
4	1.6100	0.3825	+1.2275
5	0.4007	0.1996	+0.2011
6	0.8350	1.1580	-0.3230
7	0.3375	0.2620	+0.0755
8	0.6333	0.1461	+0.4872
9	1.5561	1.2487	+0.3074
10	0.2873	0.3244	-0.0371
11	0.4210	0.4406	-0.0196
12	0.5965	0.3481	+0.2484
Average[3]	0.7016	0.4639	+0.2377

b) Accident costs

Locations	Freeways	Parkways	Differences[2]
1	$ 11,642	$ 10,044	+1,598
2	$ 21,178	$ 5,279	+15,899
3	$ 18,286	$ 21,740	-3,454
4	$ 51,828	$ 10,857	+40,971
5	$ 12,924	$ 6,314	+6,610
6	$ 25,410	$ 32,170	-6,760
7	$ 11,269	$ 7,108	+4,161
8	$ 21,142	$ 4,262	+16,880
9	$ 48,843	$ 40,610	+8,233
10	$ 11,368	$ 8,531	+2,837
11	$ 16,972	$ 15,092	+1,880
12	$ 15,732	$ 9,259	+6,473
Average[3]	$ 22,216	$ 14,272	+7,944

1. 1994 Dollars.
2. The values are obtained by deducting the FAR (or AC) of the parkway from the FAR (or AC) of the freeway.
3. This is average of 12 locations averaged over 7 years.

TABLE 5 The Average FAR and AC in Terms of Locality

	Urban Cases			**R**ural Cases		
	Freeways	Parkways	Difference[1]	Freeways	Parkways	Difference[1]
Average FAR per 100 Million VMT	0.6353	0.3362	0.2991	0.8279	0.7193	0.1086
Average AC (1994 Dollars)	$ 19,979	$ 10,712	$ 9,267	$ 26,691	$ 21,393	$ 5,298

1. The values are obtained by deducting the FAR (or AC) of the parkway from the FAR (or AC) of the freeway.

TABLE 6 The Proportions of Driver Factors Related to Fatal Crashes

Driver Factors Related to Fatal Crashes	Freeways[1]	Parkways[2]
Alcohol & drug involved (A&D)	15.50%	20.93%
Drowsy, sleepy, asleep, and fatigued reported (D)	4.93%	7.56%
Inattentive reported (I)	13.03%	14.53%
Running-off-road or failure to keep in proper lane reported (ROR)	22.89%	31.40%
Driving too fast for conditions reported (DTF)	16.20%	23.84%
Failure to obey traffic rules reported (FTR)	10.56%	4.07%
Driver error reported (DE)	8.10%	10.47%
Operation error reported (OE)	2.82%	3.49%
Weather or surface condition related (WS)	3.17%	4.07%
Other (O)	12.32%	6.40%
Unknown and none (U&N)	15.14%	8.14%
Total	124.66%	134.90%

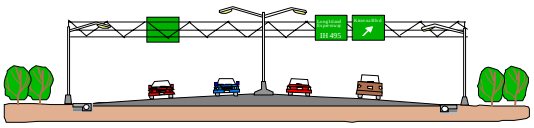
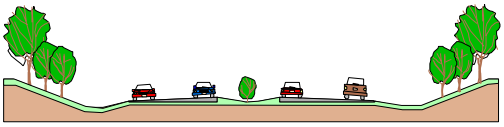
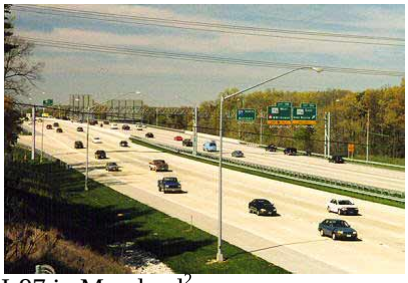
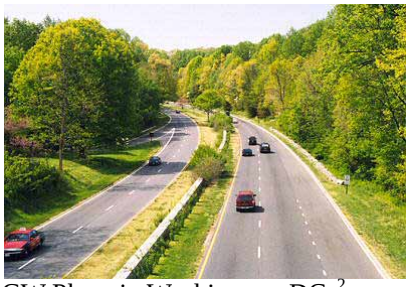
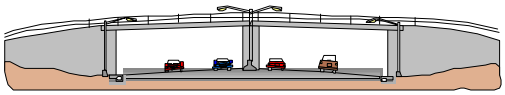
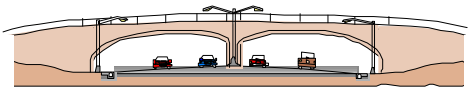
1. Driver factors were analyzed based on a total of 284 fatal crash data at the freeway sections.
2. Driver factors were analyzed based on a total of 172 fatal crash data at the parkway sections.

TABLE 7 The Proportions of 'D' and 'I' Factors Related to Fatal Crashes in Terms of Locality

'Drowsy, sleepy, asleep, and fatigued' (D)				'Inattentive' (I)			
Urban Cases		Rural Cases		Urban Cases		Rural Cases	
Freeways	Parkways	Freeways	Parkways	Freeways	Parkways	Freeways	Parkways
5.13%	3.33%	4.49%	12.20%	14.36%	7.78%	10.11%	21.95%

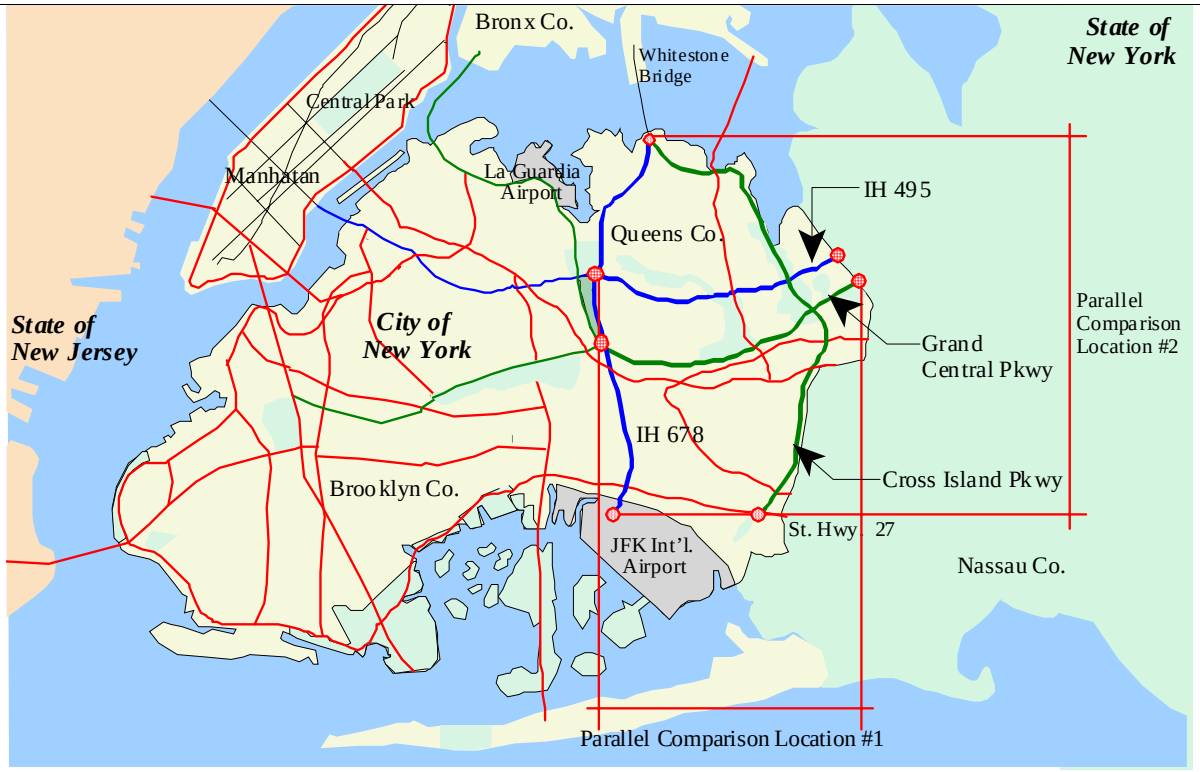
TABLE 8 The Proportions of 'Relation to Roadway' of Fatal Crashes

Relation to Roadway	Freeways	Parkways
On roadway	38.73%	25.58%
Shoulder	10.21%	4.65%
Intersection/entrance/exit ramp	15.49%	6.98%
Median	6.69%	11.05%
Roadside	13.38%	31.40%
Running off road & outside of right-of-way	7.04%	15.12%
Gore	0.70%	1.74%
Construction & maintenance zone	2.46%	2.32%
Unknown & none	5.30%	1.16%
Total	100.00%	100.00%

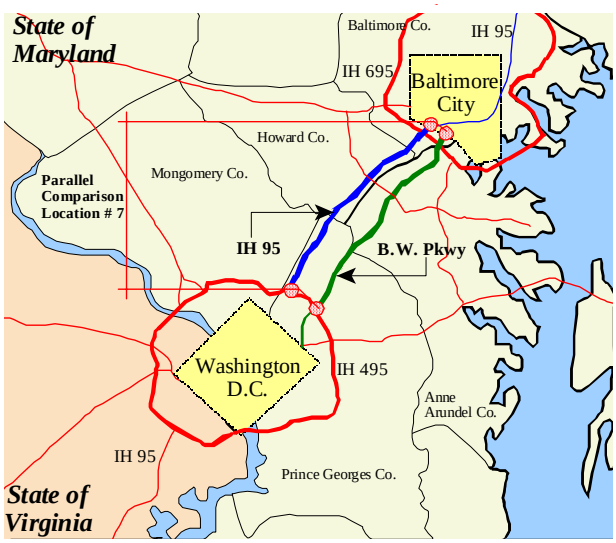
	Landscape Characteristics in Freeways	Landscape Characteristics in Parkways
Median and shoulder: types and length[1]	 - Raised Concrete Barrier (RCB). - Asphalt Paved Shoulder, Right shoulder:10 ft Left shoulder: 4 to 6 ft, paved on four-lane and 10 ft, paved on six-lane.	 - Grass or Vegetated Median. - Glass Shoulder or clearance. The width of shoulder is varied based on locations.
Landscape in surround-ings	 I-97 in Maryland[2] Limited landscaped transition between travelways and surroundings.	 GW Pkwy in Washington, DC. [2] Parkway design respects that surrounding urban and natural landscape minimizes artificial elements. The edges of parkways visually blend into the surrounding landform. Also, landscaped medians lay the road gently on the road.
Bridges	 - Concrete block bridge	 - Historic bridge (Arch type)
Clear zone[3]	30 ft., all freeways, qualifications based on locations.	Vary from 10 to 15 ft., less in urban locations.

1. Shoulder width criteria are now AASHTO guidelines.
2. Permission to use images is granted by Intersystem Concepts, Inc., http://www.trainweb.org/oldmainlane/bwamake3.htm. Accessed Nov. 9, 2002.
3. Clear zone dimensions are now AASHTO guidelines.

FIGURE 1 Landscape differences of selected parallel comparison sections of parkways and freeways.



a) comparison study location No. 1: IH 495 and Grand Central Pkwy.
comparison study location No. 2: IH 678 and Cross Island Pkwy.



b) comparison study location No. 7: IH 95 and Baltimore Washington Pkwy.

c) comparison study location No. 8: US 9 and. Garden State Pkwy. (Cape May Co.)
comparison study location No. 9: US 9 and Garden State Pkwy. (Ocean & Burlington Co.)

FIGURE 2 Examples of parallel comparison sections of parkways and freeways.

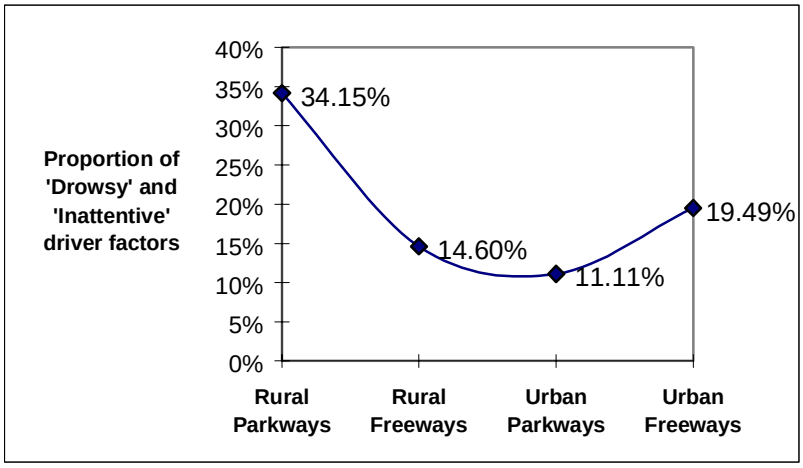


FIGURE 3 The proportions of 'drowsy' and 'inattentive' driver factors at four types of study sections.